



# LA3376

## Pilot Cancel-Provided PLL FM MPX Demodulator for Car Stereos

### Overview

The LA3376 is a multiplex IC for use in car stereo applications. It contains 2 functions of skip noise control and pilot cancel and is packaged in 16-pin SEP

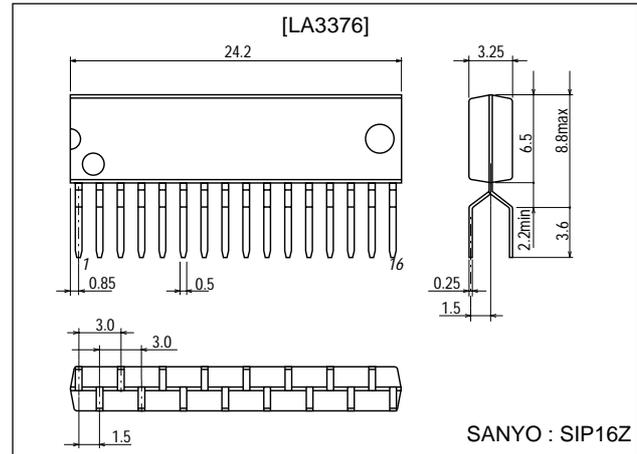
### Functions

- Pilot canceler (level-follow-up type).
- Stereo noise controller (SNC function).
- High-cut controller (HCC function).
- Automatic selection between stereo and monaural.
- VCO oscillation stop
- Forced monaural function (stereo lamp off, pilot cancel and HCC function hold) of reception mode is realized by disconnecting pin 10 from  $V_{CC}$ .

### Package Dimensions

unit:mm

#### 3193-SIP16Z



Method of forced monaural at stereo reception	LA3375	LA3376	Lamp	HCC	Pilot cancel
PIN 8 GND	○	○	ON	○	○
7.3V or more applied to PIN 7	○	○	OFF	×	×
PIN 11 GND	○	○	OFF	○	×
PIN 10 disconnected	×	○	OFF	○	○

### Features

- Low distortion (0.05% typ 300mV input mono).
- Good ripple rejection of power supply (35dB typ.).
- Wide supply voltage range ( $V_{CC}$ =6.5 to 14V).
- Good space factor due to single-end package.
- Easy to draw printed circuit pattern due to pin-to-pin space of 3mm.

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## Specifications

### Absolute Maximum Ratings at $T_a = 25^\circ\text{C}$

Parameter	Symbol	Conditions	Ratings	Unit
Maximum power supply voltage	$V_{CC}$ max		16	V
Lamp driving current	$I_L$ max		30	mA
Allowable power dissipation	$P_d$ max	$T_a \leq 45^\circ\text{C}$	520	mW
Operating temperature	$T_{opr}$		-20 to +70	$^\circ\text{C}$
Storage temperature	$T_{stg}$		-40 to +125	$^\circ\text{C}$

### Recommended Operating Conditions at $T_a = 25^\circ\text{C}$

Parameter	Symbol	Conditions	Ratings	Unit
Recommended power supply voltage	$V_{CC}$		6.5 to 14	V
Input signal voltage	$V_i$		200 to 300	mV

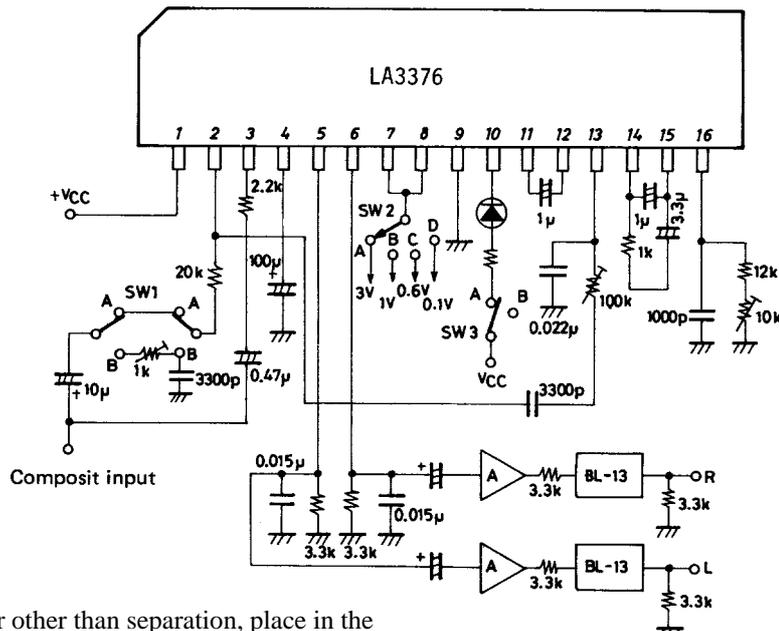
### Operating Characteristics at $T_a = 25^\circ\text{C}$ , $V_{CC}=10\text{V}$ , $V_i=300\text{mV}$ , $f=1\text{kHz}$ , $L+R=90\%$ , $\text{pilot}=10\%$ ,

See specified Test Circuit.

Parameter	Symbol	Conditions	Ratings			Unit
			min	typ	max	
Quiescent current	$I_{cco}$			22	28	mA
Channel separation	Sep		40	50		dB
Monaural distortion factor	mono THD	mono=300mV		0.07	0.2	%
Stereo distortion factor	ST THD	main		0.07	0.2	%
Lamp lighting level	$V_L$	$L+R=90\%$ , $\text{pilot}=10\%$	60	85	120	mV
Hysteresis	$h_v$			3	6	dB
Capture range	CR	$\text{pilot}=30\text{mV}$		$\pm 3$		%
Output signal level	$V_o$	sub	150	215	300	mV
S/N ratio	S/N	$R_g=20\text{k}\Omega$	68	74		dB
		$R_g=10\text{k}\Omega$	70	78		dB
Input resistance (pin 2)	$r_i$			20		$\text{k}\Omega$
SCA rejection ratio	$SCA_{rej}$			80		dB
Allowable input voltage	$V_i$	THD=1%, $R_g=20\text{k}\Omega$	700	900		mV
		THD=1%, $R_g=10\text{k}\Omega$		450		mV
SNC output attenuation	$A_{tt}$ SNC	$V_g=0.6\text{V}$ , $L-R=90\%$ , $\text{pilot}=10\%$	-8.5	-3.0	-0.3	dB
SNC output voltage	$V_o$ sub	$V_g=0.1\text{V}$ , $L-R=90\%$ , $\text{pilot}=10\%$			5	mV
HCC output attenuation	$A_{tt}$ HCC 1	$V_7=0.6\text{V}$ , $L+R=90\%$ , $\text{pilot}=10\%$	-15.0	-9.0	-0.5	dB
	$A_{tt}$ HCC 2	$V_7=1\text{V}$ , $L+R=90\%$ , $\text{pilot}=10\%$	-2.0		0	dB
Power supply ripple rejection	$R_r$			35		dB
VCO stopping voltage	VCO stop			7.3		V
Channel balance	CH Ba			0.5	1.5	dB
Pilot cancellation factor	$CL_p$		20	27		dB
Stereo lamp current	$I_L$	Min, stereo operating current	0.5			mA
Saturation voltage (pin 10)	$V_{sat}$	$I_L=10\text{mA}$		1.0		V

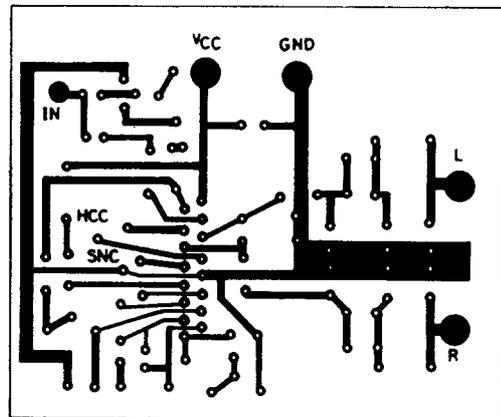
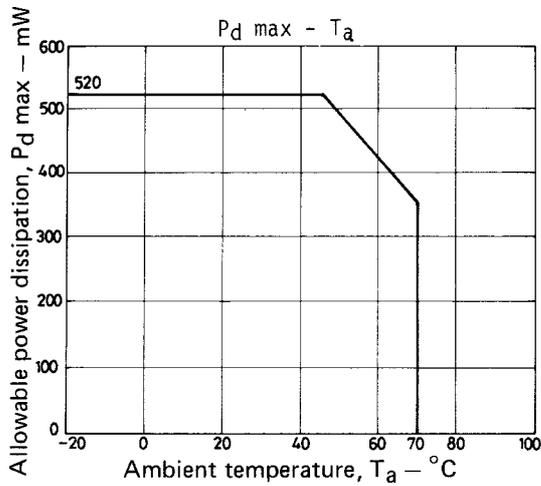
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## Specified test circuit



- SW1 : For other than separation, place in the A position.
- SW2 : For other than HCC, SNC, place in the A position.
- SW3 : Forced monaural SW of reception mode.

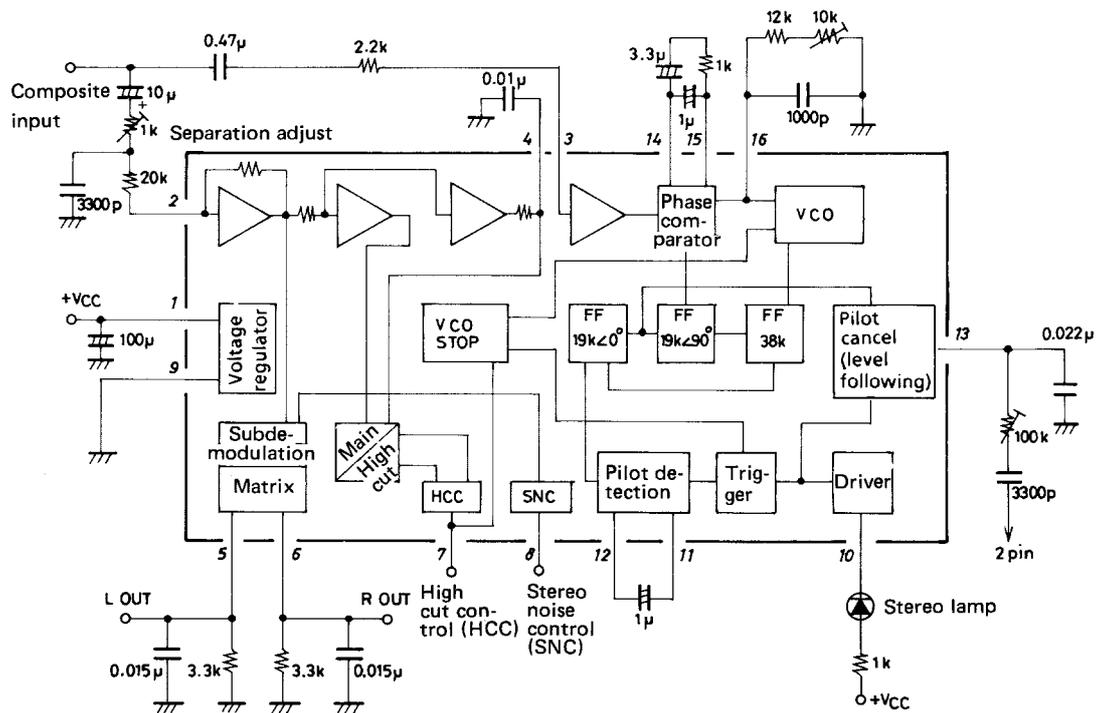
Bandwidth 100kHz, THD = 0.01% or less  
Input impedance 330kΩ or more



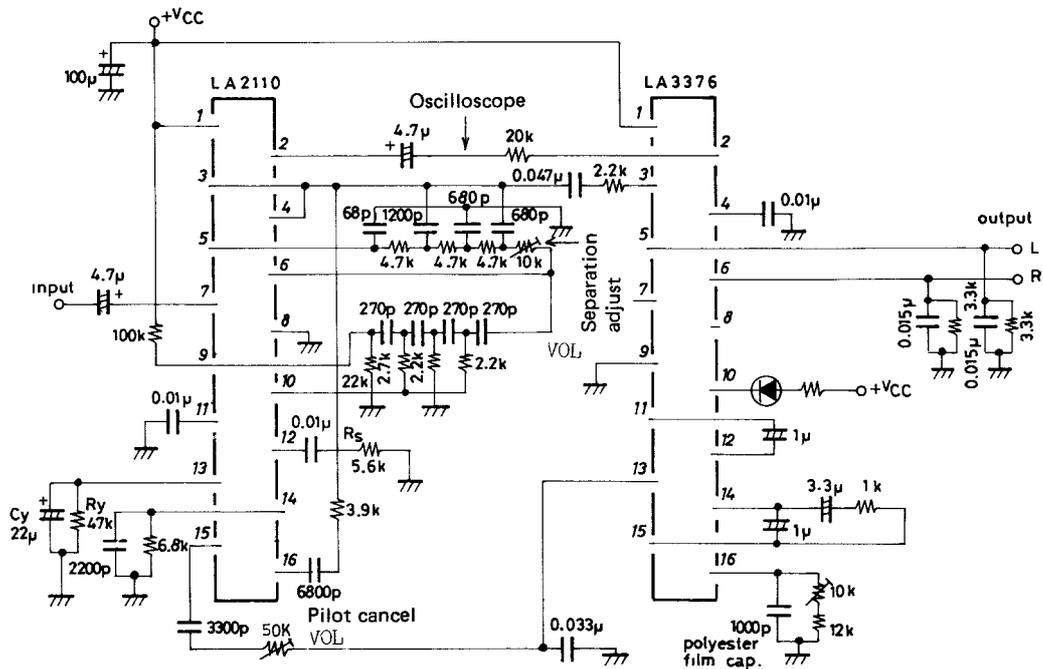
Sample printed circuit pattern

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## Sample application circuit 1



## Sample application circuit 2 : sample circuit for LA2110 and LA3376

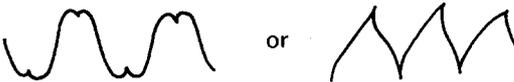


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Cautions when employing sample application circuits

- 1) Adjust separation by 10kΩ potentiometer in low pass filter.
- 2) Adjust R<sub>S</sub> for noise detection sensitivity under strong to medium radio fields. Set at appropriate value.
- 3) Adjust noise AGC by C<sub>Y</sub> and R<sub>Y</sub> to enhance noise suppression in medium to weak radio fields.
- 4) Adjust pilot cancellation by 50kΩ potentiometer connected to pin 15 of LA2110.
- 5) Reponse speeds of pilot cancellation to follow levels can be varied by adjusting capacitance value of 1μF capacitor connected across pins 11 and 12 of LA3376. Distortion factors deteriorate with reduction in value.
- 6) Adjusting pilot cancellation.

For example consider the sample application circuit 2. Assume the input signal consists only of pilot signals. First connect an oscilloscope and a valve voltmeter to pin 2 of the LA2110. Set their ranges for V : 200mV/div. AC, H : 20μs/div.

When oscilloscope waveform is  or

turn pilot cancel control to change it to the following :



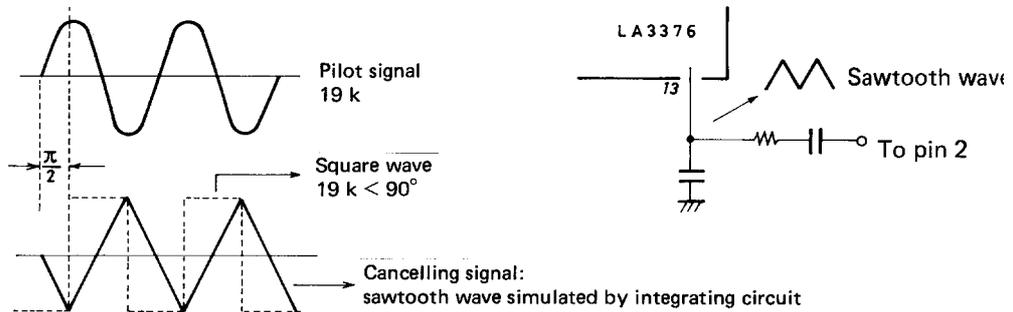
Then, adjust pilot cancel control to minimize indications of valve voltmeter.

When the LA3376 alone is used (sample application circuit 1), adjust cancel control through a 19kHz BPF to minimize carrier leakage level at output pins (pins 5 and 6).

\*Refer to the LA2110 catalog for LA3376/LA2110 applications and characteristics.

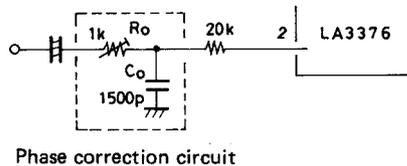
## 1. Pilot cancelling circuit

A level-following type has been used. Once set, it can easily accommodate varying pilot modulation depths among stations. Cancelling signal is a sawtooth wave obtained by integrating a square wave that is proportionate in amplitude to pilot level with C and R.



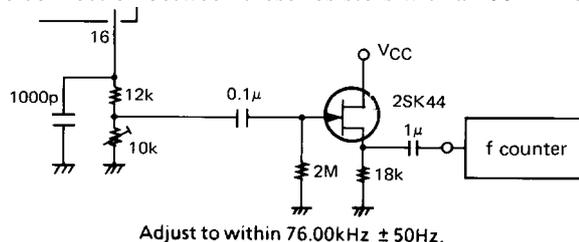
## 2. Separation adjustments

The LA3376 has separation parameters that have been set to provide maximum separation when used in conjunction with the LA2210, a noise-canceller IC, or the equivalent. The LA3376 by itself exhibits separation only in a 25 to 30dB range. If a phase correction circuit is provided in the LA3376 input circuit, it can exhibit intrinsic separation characteristics, typically 50dB.



## 3. Adjusting the free running frequency

Use a timing set resistor and a semi-set resistor, when connecting a frequency counter. Connect the counter with a high impedance input to the connection between these resistors with a 100-kΩ resistor, as shown in figure 1.



4. SNC (stereo noise control) and HCC (high-cut control)

The LA3376 has SNC and HCC terminals for improved S/N ratios when operating in weak radio fields. By adjusting the SNC terminal, noises unique to stereo FM in weak fields can be reduced. The HCC terminals permits further improvement of effective S/N ratios by lowering treble levels of FM noises in weak fields. (See Fig. 2)

STEREO deteriorates approximately 21.7dB (compared to MONO) in weak radio feilds (Fig. 2). Generally, when S/N ratios deteriorate below 30 to 40dB, noises become quite noticeable. Section (1) shows ways to set SNC and HCC when radio field strengths are divided into 3 regions, A, B, and C, (Fig. 2). SNC is expected to function in region A, and HCC in region B. In region C, shallow muting is effected in the IF stage.

(1) SNC (stereo noise control)

Stereo S/N ratios deteriorate 21.7dB below monaural but can be improved by varying stereo separation. S/N improvement becomes apparent, however, only when the separation is 20dB or worse. In that case, the relation between separation and S/N improvement is shown in Fig. 5.

SNC in the LA3376 improves S/N ratios in weak radio fields by varying separation. It varies subsignal demodulation level and controls separation. By using the IF stage signal meter level output as the source of the control signal, S/N ratios in region A of Fig. 2 can be maintained at about 40dB or better. Ideal S/N enhancements should provide gradual switching over from stereo to monaural to maintain constant S/N ratios, starting from a point in region A for 40-dB stereo S/N toward a point for 40-dB monaural S/N. Methods to set the control level will be described later.

Fig. 3 shows voltages applied to pin 8 (SNC terminal) of the LA3376 versus separation characteristics (SNC characteristics). Pin 8 is also the base of a PNP transistor, so stereo mode is set when pin 8 is open and monaural mode is set when it is grounded. SNC terminal control is effective only when locked with pilot signals and when stereo indicator is lit. External circuit parameters can be chosen in large values that do not affect the IF stage meter output circuit because SNC control currents are small. This makes designing easy. (See Fig. 6)

(2) Designing external circuits for SNC characteristics

We recommend the following as a way to designate SNC characteristics to have smooth transition of separation from stereo to monaural in region A of Fig. 2.

Separation vs S/N-enhancement relation ..... Refer to Fig. 5.

SNC terminal voltages vs separation characteristics ..... Refer to Fig. 3.

Antenna inputs vs S/N improvement characteristics can be obtained from the drawing if the graph for IF-stage signal meter output vs antenna iuput and the graph for stereo S/N-ratio vs antenna input are known. From desired S/N characteristics, SNC terminal voltage characteristics can also be obtained.

Sample drawings are shown in Fig. 4, where for simplicity's sake, SNC, IF meter, and stereo S/N characteristics have been approximated with straight lines.

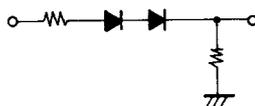
For instance :

To obtain stereo S/N improvement characteristics from SNC characteristics, when (a) in the second quadrant of the chart represents bare SNC characteristics, point 1 projected to the third quadrant shows a 20dB separation and a 1dB S/N improvement. When projected from the frist to the fourth quadrant, a point improved by 1dB in S/N over the stereo S/N line in the fourth quadrant corresponds to point 1.

Similarly, point 2 on the SNC characteristics in the second quadrant corresponds to point 2 in the fourth quadrant. Point 3 in the second quadrant corresponds to point 3 in the fourth quadrant. Stereo S/N improvement characteristics for each point are obtainable.

Similarly, (b) characteristics in the second quadrant are projected to form (b) characteristics in the fourth quadrant, and (c) in the second quadrant to form (c) in the fourth quadrant, thus providing a way to diagram improvement characteristics.

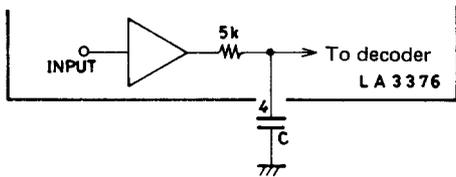
In the resulting drawings, ideal S/N improvement characteristics are similar to (b) in the fourth quadrant, but corresponding SNC characteristics have to be (b) characteristics in the second quadrant which are difficult to realize. Among realistic characteristics, something like (c) appears to be satisfactory. The (c) SNC characteristics are obtained with a shift by two diodes together with a 1/2 bleeder.



(3) HCC (high-cut control)

In region B where S/N deteriorates to 40dB or worse even for monaural, the S/N as sensed by the human ear can be enhanced by suppressing levels at frequencies above approximately 7kHz.

Treble region levels that follow meter voltages can be smoothly attenuated (high-cut control) by impressing IF-stage signal meter output to the HCC pin (pin 7) of the LA3376. Fig. 7 shows MPX output frequency characteristics (monaural) provided by voltages impressed on pin 7. Frequency characteristics for a 100% high cut can be designated by an external capacitor connected to pin 4. An equivalent circuit is shown below where the designation is made by the 5kΩ and the C time constant. Approximate values provided by C as expressed in attenuation at 10kHz are listed in table below : right.



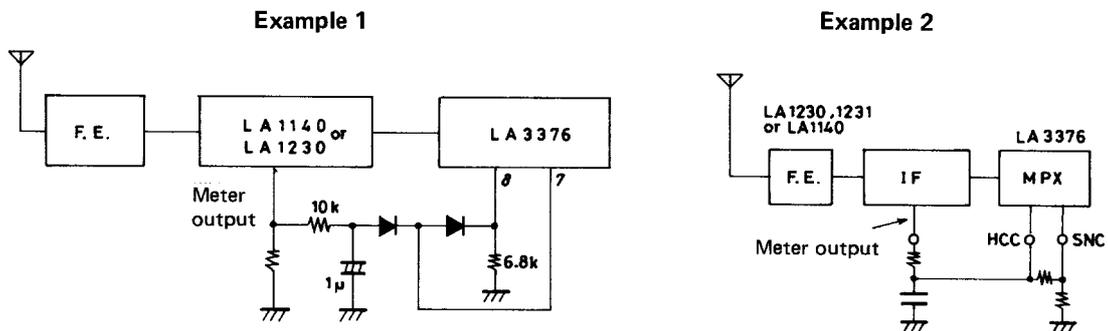
C [ μF ]	Attenuation at 10 kHz (dB)
0.01	-11
0.033	-21
0.047	-25
0.068	-28

Fig. 8 shows the relation between voltages impressed on pin 7 and rates (%) of high cut (HCC). When IF meter output voltage characteristics and region B, S/N characteristics, of Fig. 2 have been obtained, S/N improvement by HCC can be drawn in a way similar to drawing SNC characteristics.

Fig. 2 shows typical meter outputs of a quadrature detection IF amplifier IC. (Fig. 1 shows data for the LA1140, LA1230, and LA1231N) HCC characteristics have been designated to permit region B improvements when the IC is directly connected to HCC (pin 7) terminal of the LA3376. The infinitesimal control currents at pin 7, similar to pin 8, do not affect meter outputs.

(4) SNC and HCC connection circuits when coupled with the IF stage

Fig. 1 shows sample S/N characteristics vs antenna inputs when SNC and HCC are connected with the IF stage by an external circuit.

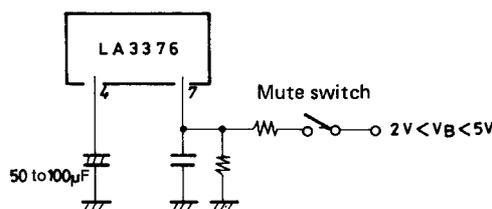


(5) S/N improvements in region C of Fig. 1

Because S/N ratios deteriorate even further in the region C of Fig. 1, it is better to improve the S/N in this region with IF mutings. The LA1140 is available to linearly vary the IF muting. Employment of the LA3376 together with the LA1140 further enhances S/N improvement.

(6) Using the HCC terminal for muting

Mutings in the neighborhood of 37dB are feasible by utilizing HCC functions as muting functions when used in home stereos and no need exists to suppress treble noises. Fade-in and fade-out of mutings, permitting delightful, shock-noise-free muting are possible by providing a time constant to the pin 7 control.



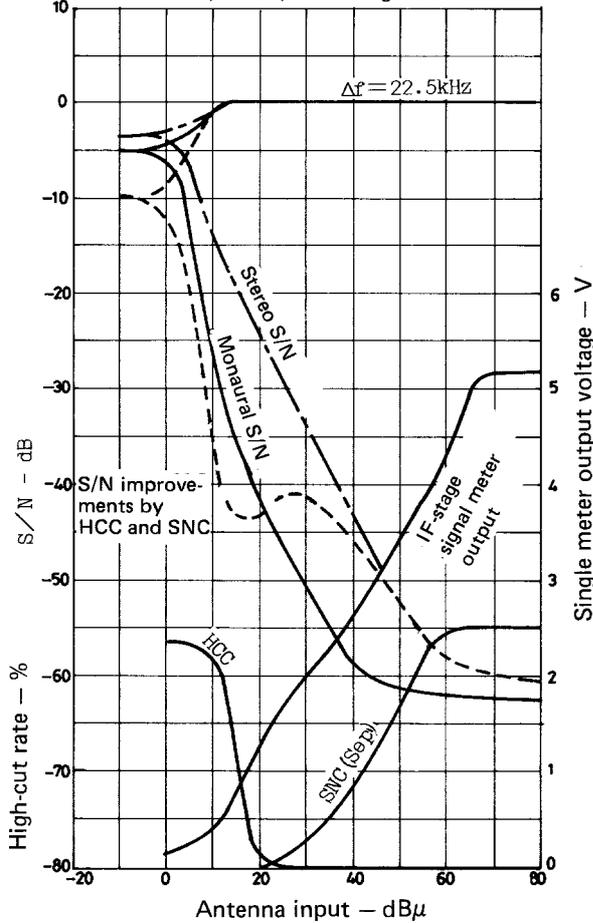
(7) VCO damping

VCO oscillations can be damped by applying a voltage not less than 7V to the HCC terminal (pin 7) to induce a monaural mode. At this time, both SNC and HCC are in an off mode. Fig. 9 shows flow-in current by voltages applied to pin 7.

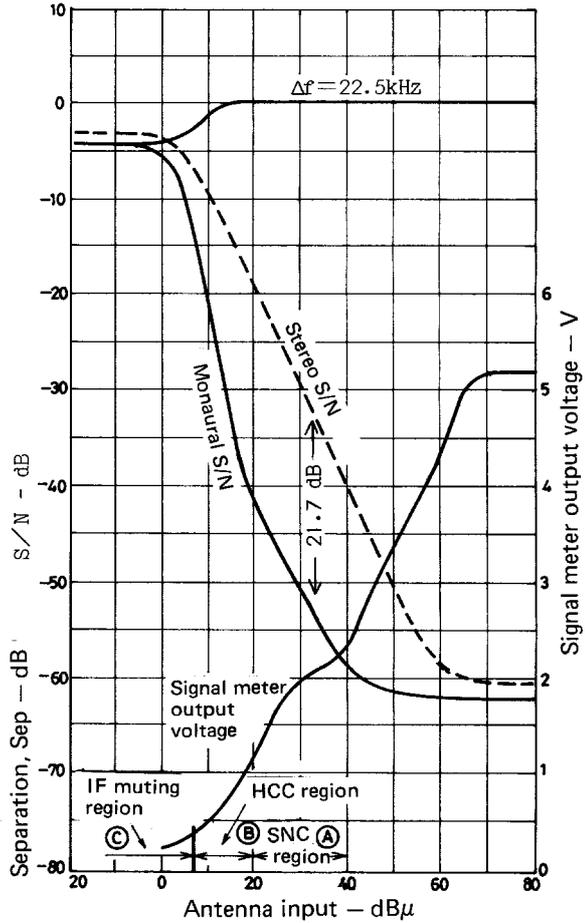
(8) Forced monaural

By disconnecting LED lamp at pin 10 from  $V_{CC}$  lamp, reception mode forced monaural mode forced function can be attained. (Stereo lamp is turned OFF. Pilot cancel and HCC function are held.)

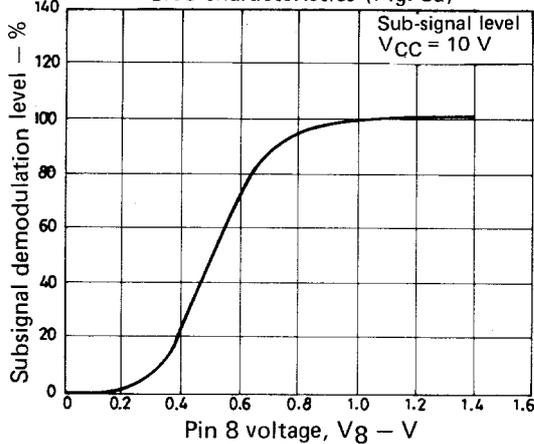
Sample weak radio field S/N improvements by the system (Fig. 1)



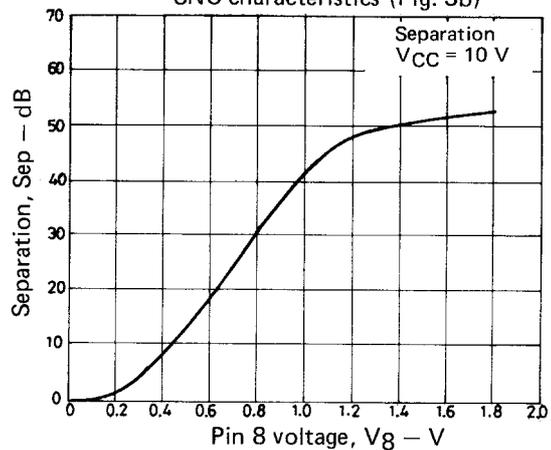
SNC and HCC operating regions (Fig. 2)



SNC characteristics (Fig. 3a)

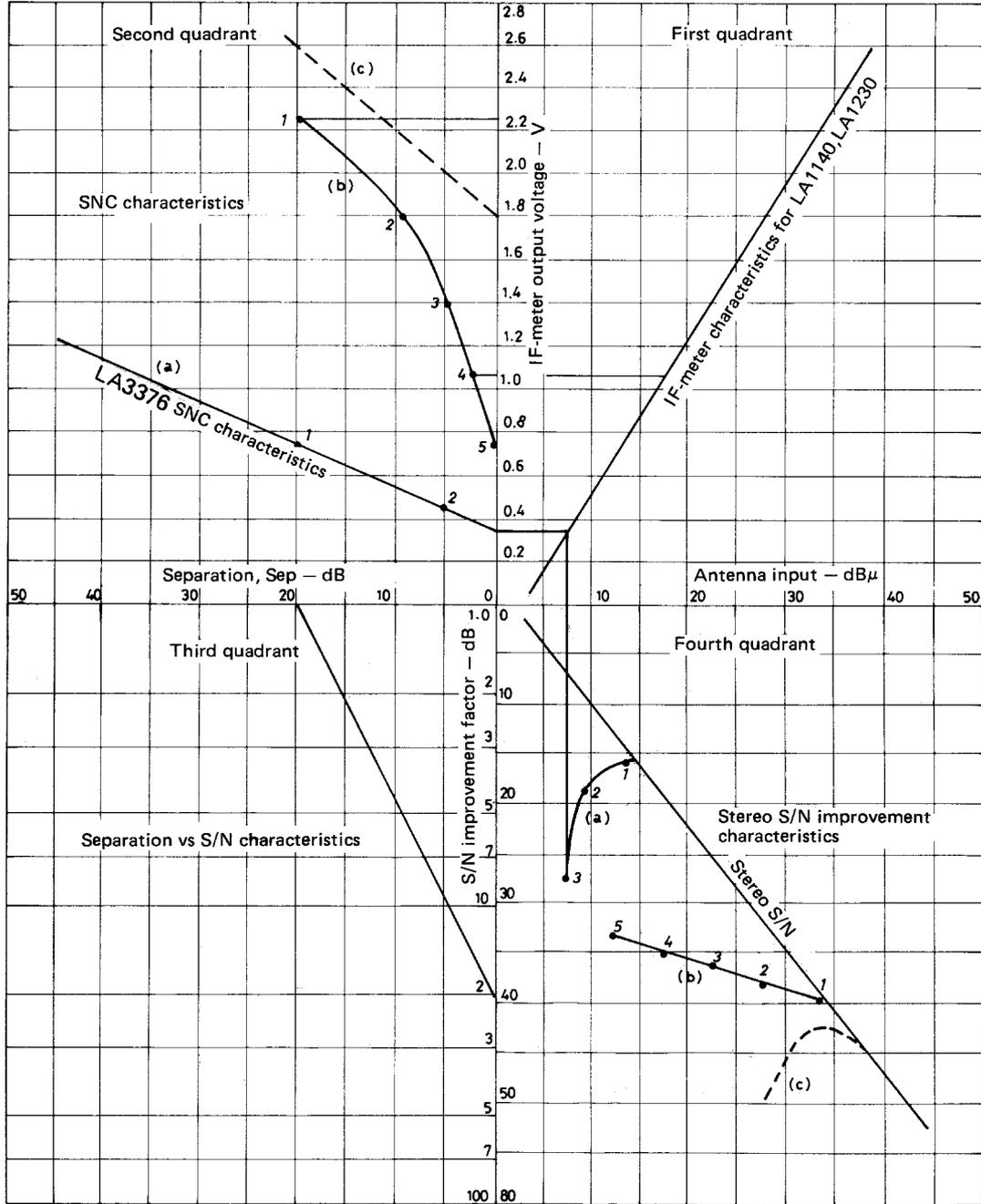


SNC characteristics (Fig. 3b)

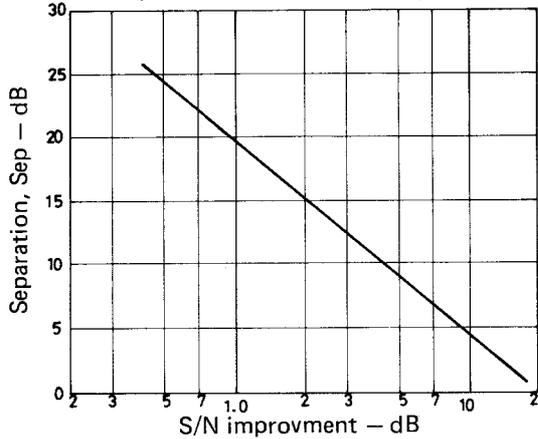


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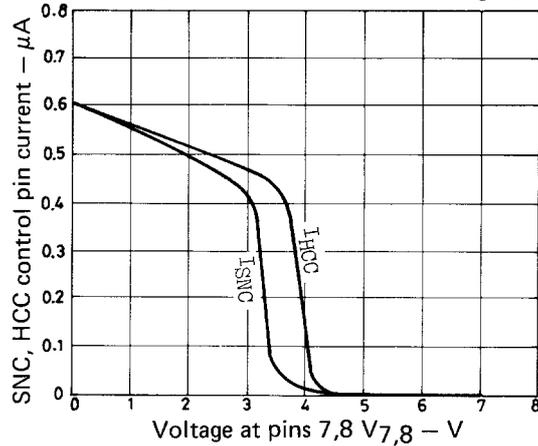
Chart to obtain stereo S/N characteristics from SNC characteristics (Fig. 4)

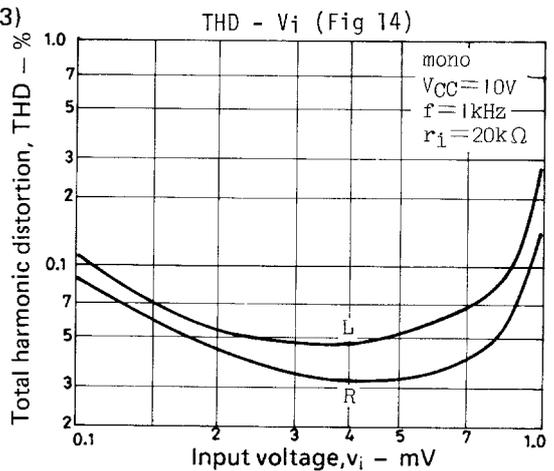
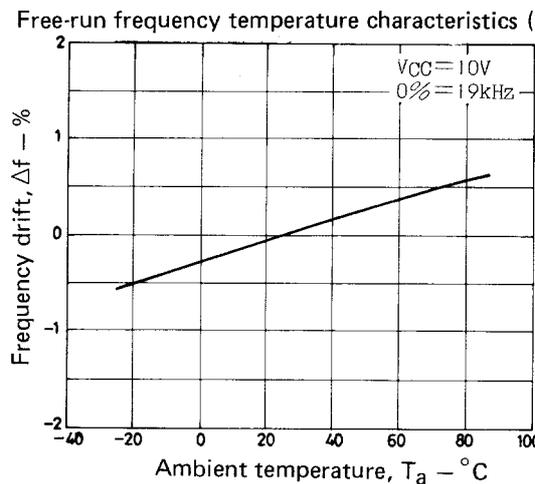
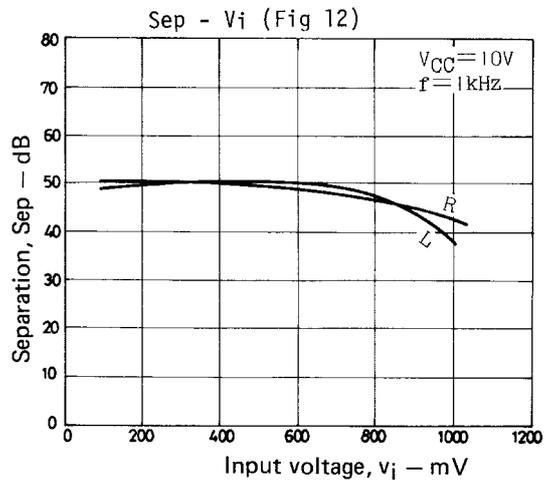
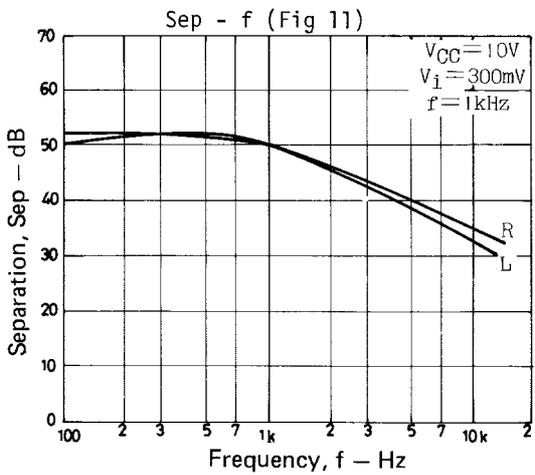
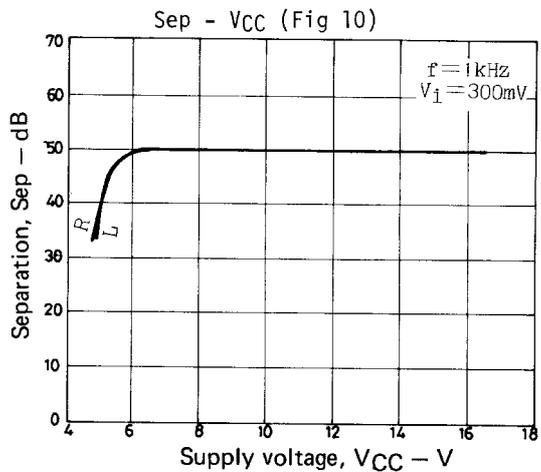
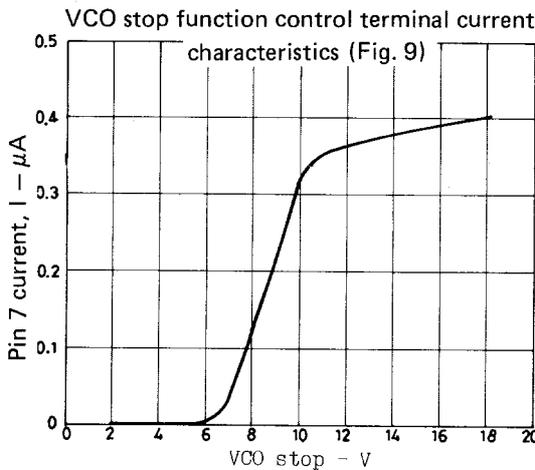
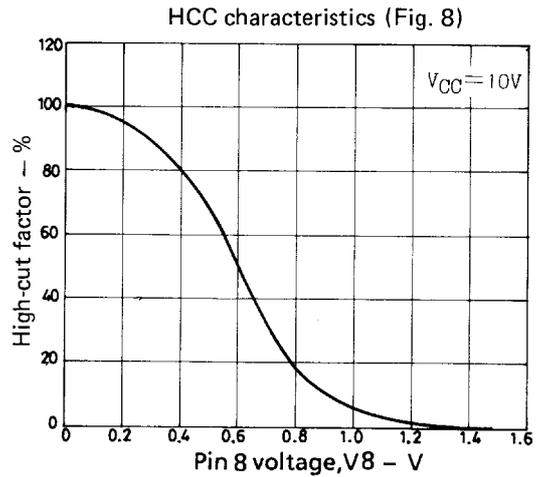
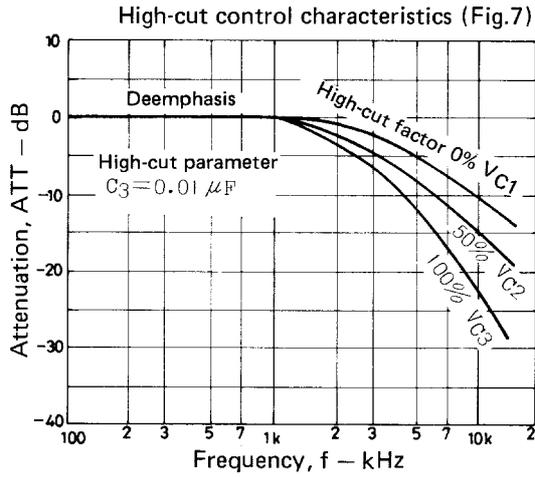


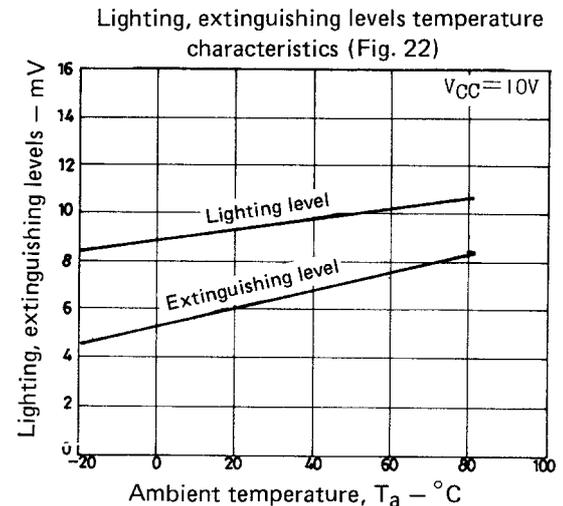
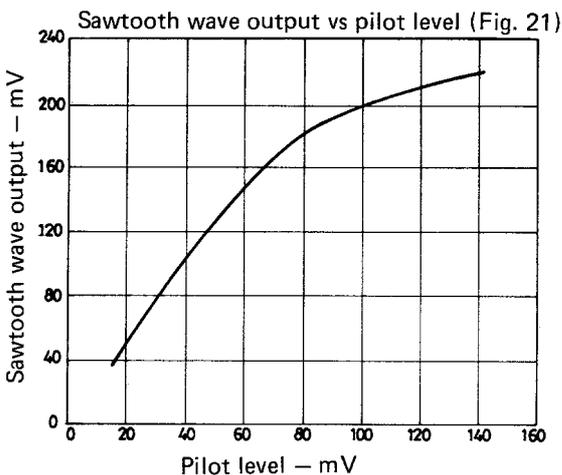
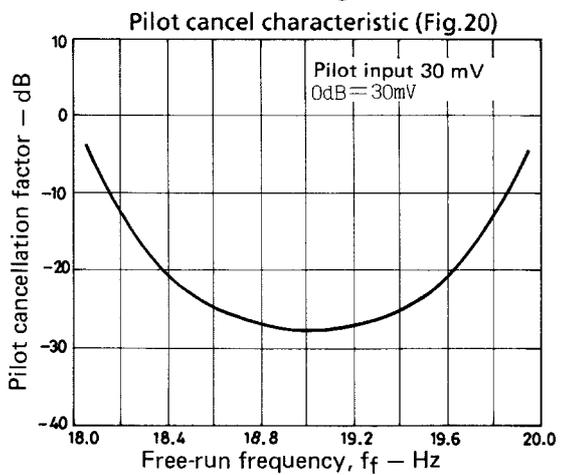
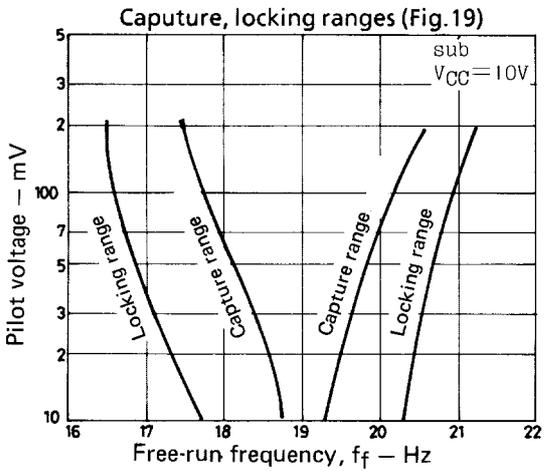
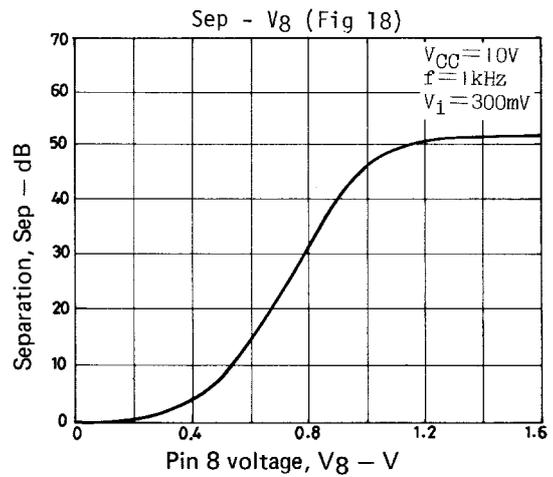
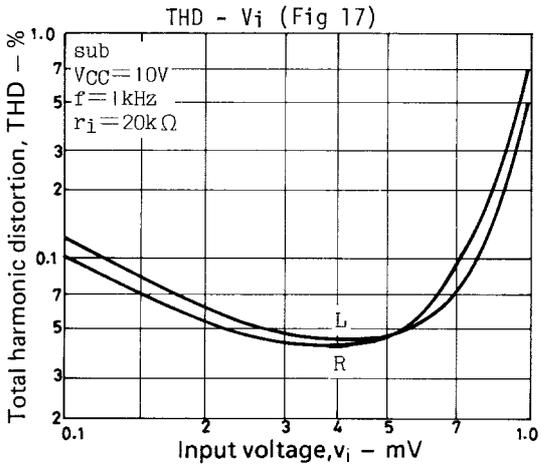
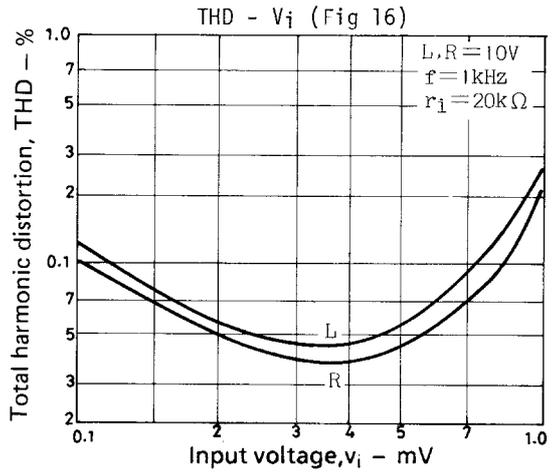
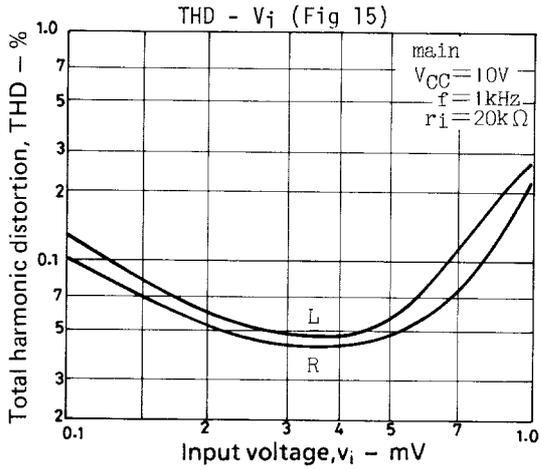
Sep - S/N improvement (Fig. 5)

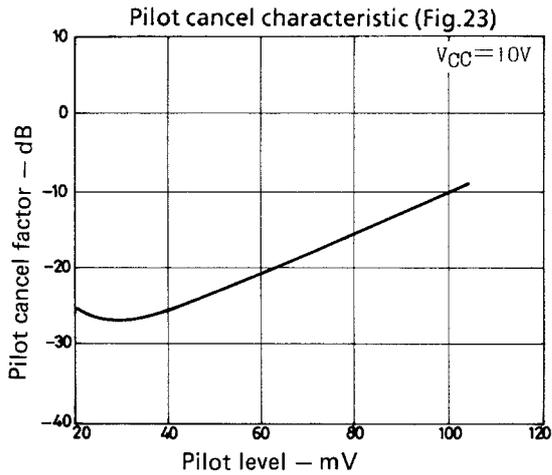


SNC, HCC control pin current (Fig. 6)









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